MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EBT4016 – COMPUTED TOMOGRAPHY

(BE)

23 OCTOBER 2018
2:30 p.m. - 4:30 p.m.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 5 pages with 4 Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) In Figure Q1, calculate the linear attenuation coefficient for bone and tissues given that the relative intensities of signals S_1 and S_2 measured by the X-ray detectors are 0.0045 and 0.05 respectively. (*Hint: relative intensity* = I_d/I_o)

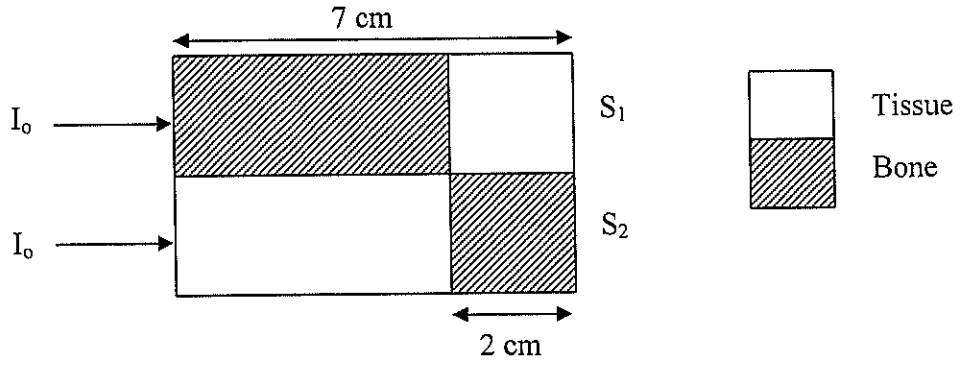

Figure Q1

[8 marks]

(b) The development of the first-generation CT scanner was begun in 1967 by Godfrey Hounsfield. If Dr. Hounsfield's scanner measured transmission of 160 rays per view, calculate the total number of measurement taken for each slice.

[2 marks]

(c) Multi-slice CT offers "substantial improvement of the volume coverage speed performance" if compared to single-slice CT.

i. What is the most significant distinction between single-slice CT and multi-slice CT in terms of technology?

[2 marks]

ii. Discuss three advantages of multi-slice CT.

[6 marks]

iii. Given that a multi-slice CT has a four-detector array and the X-ray pre-patient collimation width is 20 mm, calculate the detector row collimation of the scanner.

[3 marks]

(d) Given that a CT bone window width is set at 100 with the center at 500,

i. What range of CT numbers that will be displayed as black?
ii. What range of CT numbers that will be displayed as white?

[2 + 2 marks]

Continued...

Question 2

(a) A first-generation CT scanner is used to image a square-shaped object as shown in Figure Q2. The object has a constant linear attenuation coefficient of $\mu_0 = 2\ cm^{-1}$.

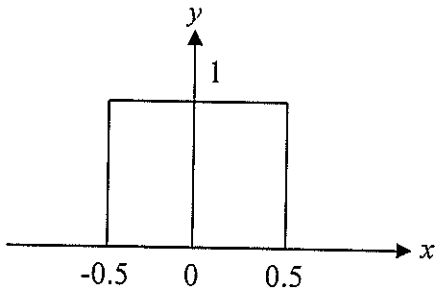

Figure Q2

i. Write a mathematical expression for the linear attenuation function $\mu(x,y)$.

[1 mark]

ii. Let $g(l)$ be the projections of $f(x,y)$. Find $g(l)$ for $\theta = 0°$, $\theta = 90°$ and $\theta = 45°$ using Radon Transform. Also, sketch the three projections and carefully label the axes.

[4 + 4 + 5 marks]

iii. Find the value $b_{45°}(0.15,0.5)$.

[6 marks]

(b) You are working on a research project to build a simple CT teaching model that is based on visible light and pencil beam principles where a laser diode is used and light is detected by a photo diode. Discuss the image reconstruction algorithm you may use in generating a phantom image.

[5 marks]

Continued...

Question 3

(a) The first commercial PET/CT scanner reached the market in 2001 and by mid-2004 over 400 PET/CT scanners were installed worldwide.

i. Explain how PET is regarded as complementary to CT scanners or vice versa.

[2 marks]

ii. What is the typical procedure for a patient undergoes a clinical PET/CT examination?

[3 marks]

iii. Image fusion has been done for both modalities by means of appropriate software tools. In your opinion, why PET/CT scanners are still the preferred choice for imaging "non-rigid" part of the body?

[3 marks]

iv. How PET/CT image fusion is done in image processing? [1 mark]

(b) Imagine that you are a radiologist observing the cranial CT images of three patients that were admitted to the hospital. Descriptions below are what you have observed from the three CT images:

i. There is a high density, concave shape hematoma lining between the dura mater and the skull. Slight midline shift is also present.

ii. There is a right sided cresentic, isodense hematoma situated between the skull and the brain with associated midline shift.

iii. There is a left sided cresentic, high density hematoma situated between the skull and the brain with associated midline shift.

Name the traumatic brain injuries indicated for i, ii and iii.

[2 x 3 marks]

(c) Surface rendering and volume rendering have been extensively applied to CT data for 3-D visualization.

i. Briefly explain both techniques. [4 + 4 marks]

ii. Volume rendering approach is superior to surface rendering approach. Explain why.

[2 marks]

Continued...

Question 4

Assume that the relaxation time T_1 and T_2 for gray matter and white matter in the brain are given as in Table Q4, answer the following questions:

Table Q4

Tissues	**T_1 (*ms*)**	**T_2 (*ms*)**
Gray matter	800	100
White matter	700	90

i. Explain the terminologies of T_1 and T_2. [4 marks]

ii. The net magnetization of a sample of gray matter is rotated into the *xy*-plane and allowed to decay. What fraction of the transverse magnetization, M_{xy} will be present 40 *ms* after being placed in the plane?

[4 marks]

iii. Sketch the graph of M_{xy} in (ii) for gray matter. In your graph, include the M_{xy} value at T_2.

[4 marks]

iv. The net magnetization of a sample of gray matter was set equal to zero after RF pulse excitation. After RF transmitter is turned off, the net magnetization recovers towards its equilibrium value. After 1.0 *s*, what fraction of the equilibrium magnetization, M_z will be present?

[4 marks]

v. Sketch the graph of M_z in (iv) for gray matter. In your graph, include the M_z value at T_1.

[4 marks]

vi. Which of the following pulse sequence would the white matter appear lighter than gray matter in the image? Choose one and elaborate your reasoning.

1. TR = 750 *ms*, TE = 20 *ms*
2. TR = 2000 *ms*, TE = 750 *ms*
3. TR = 2000 *ms*, TE = 95 *ms*
4. TR = 1500 *ms*, TE = 200 *ms*

[5 marks]

End of Paper